Optimal Physics Ensemble to Improve Extreme Event Probability Prediction

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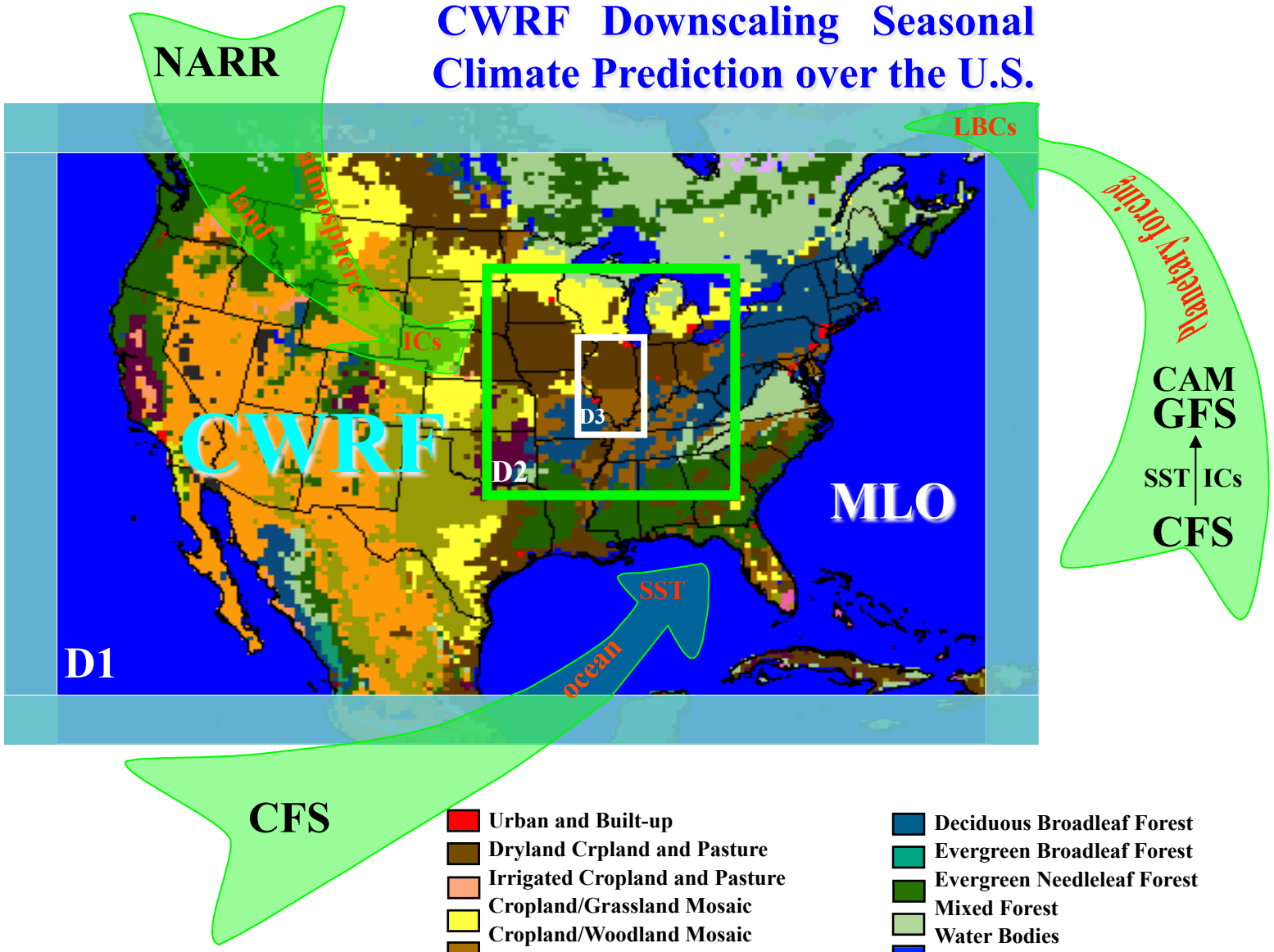
CWRF Downscaling Seasonal Climate Prediction over the U.S.



NOAA

2008-2011

CWRF Tornado Like (?)

- May 2003 –

  Tornado extreme season in the United States

  More than 600 tornados observed within one month

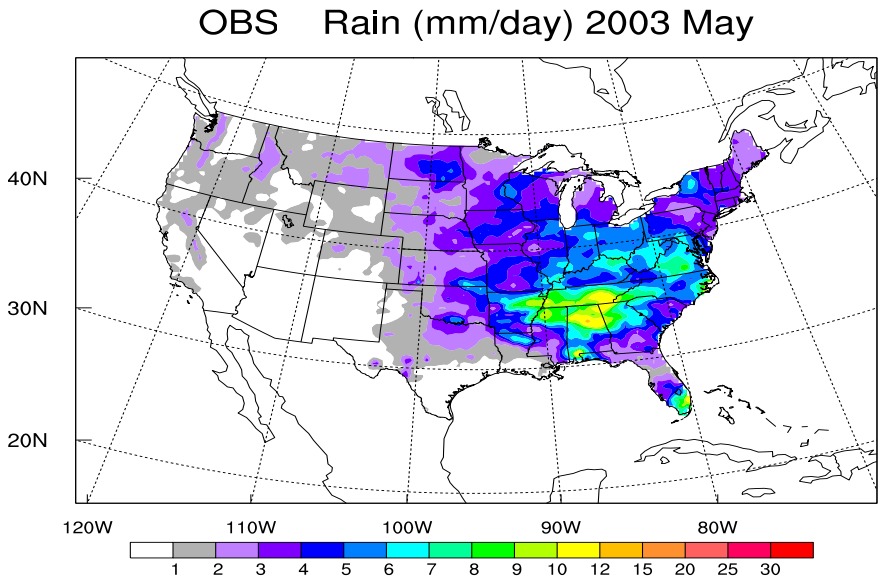
- RCM Downscaling Simulation

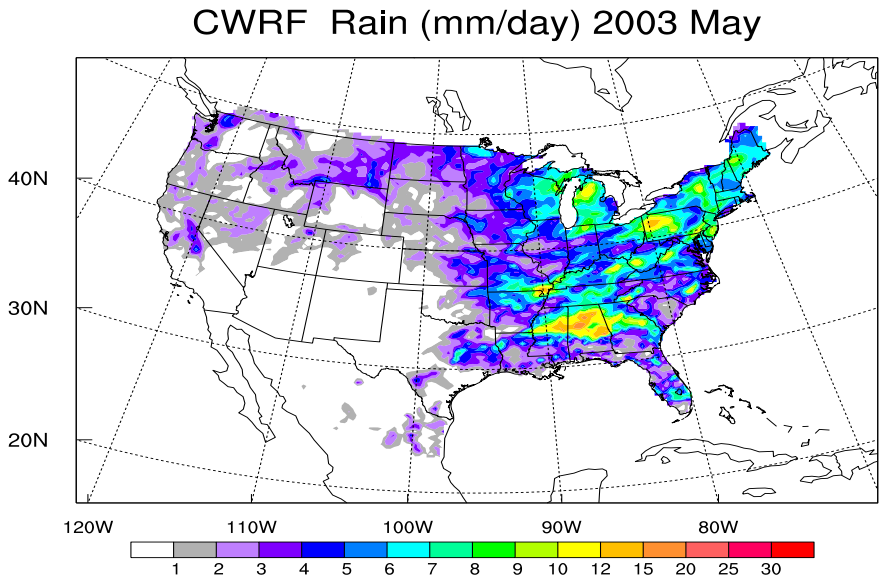
  Compare CWRF and CMM5 to illustrate physics configuration sensitivity

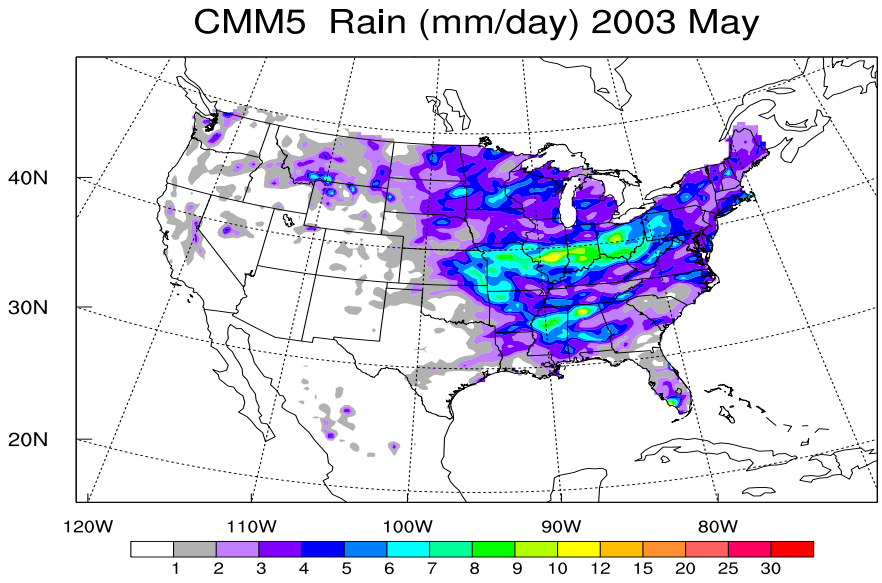
  Use CWRF instability measure as an indicator for tornado potential

  Run RCMs at 30-km continuously driven only by LBCs from NCEP RII

Monthly Mean Precipitation of May 2003



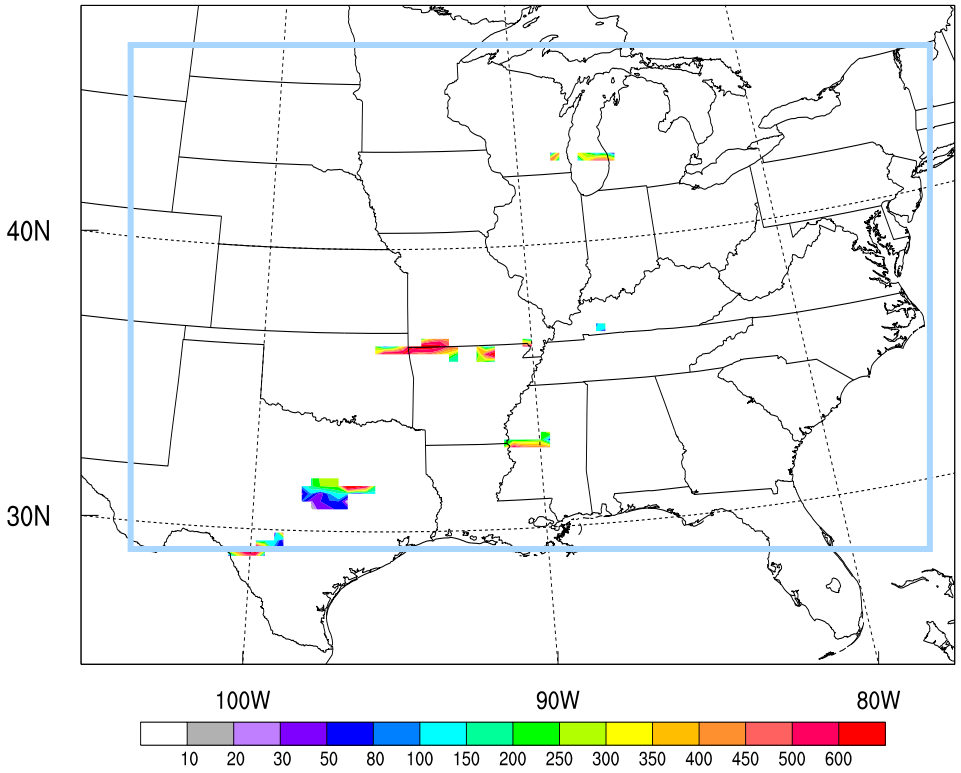




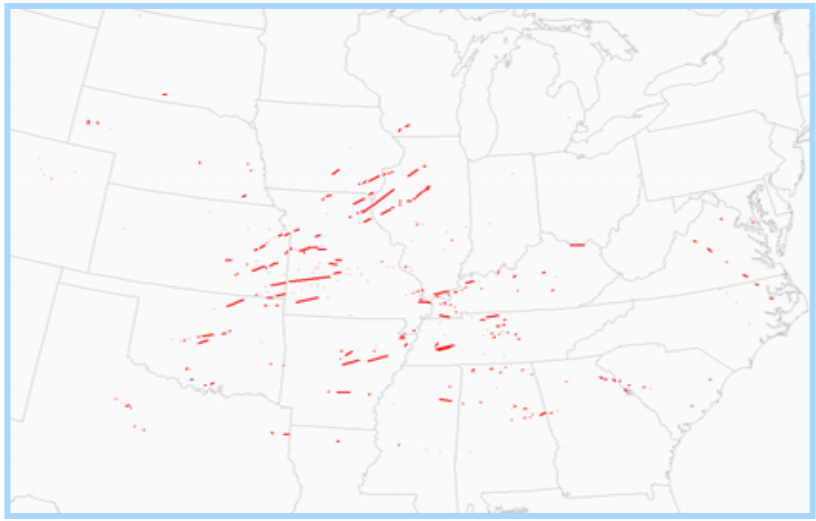
Average precipitation (mm/day) for May 2003 from observations, CWRF and CMM5 simulations. Clearly CWRF captured the major characteristics of the observed heavy rainfall in the central eastern U.S., while CMM5 did not. It indicates more credibility of underlying physics and dynamics in CWRF. Note that global scale circulation information is passed from the same NCEP RII reanalysis to CWRF and CMM5 at their lateral boundaries.

An Optimized Ensemble of CWRF and CMM5 shall better capture OBS

Frequency of CWRF Unstable Incidences
May 3-11, 2003



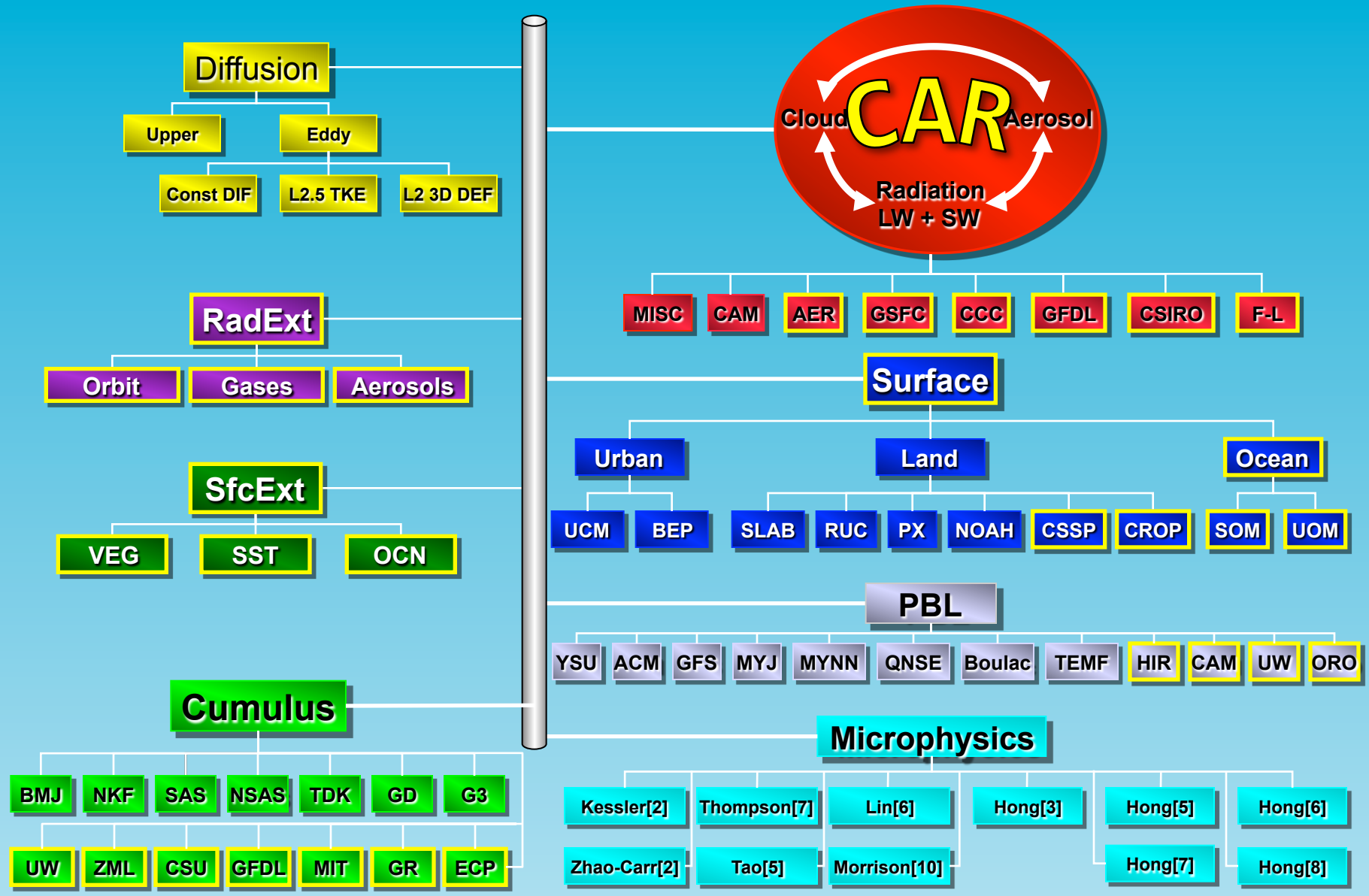
Observed Tornado Tracks
May 3-11, 2003



CWRF was run at a relatively coarse resolution (30-km) and in a climate mode without DA

This was just a preliminary trial, where numerical unstability was chosen subjectively; fine tuning may help

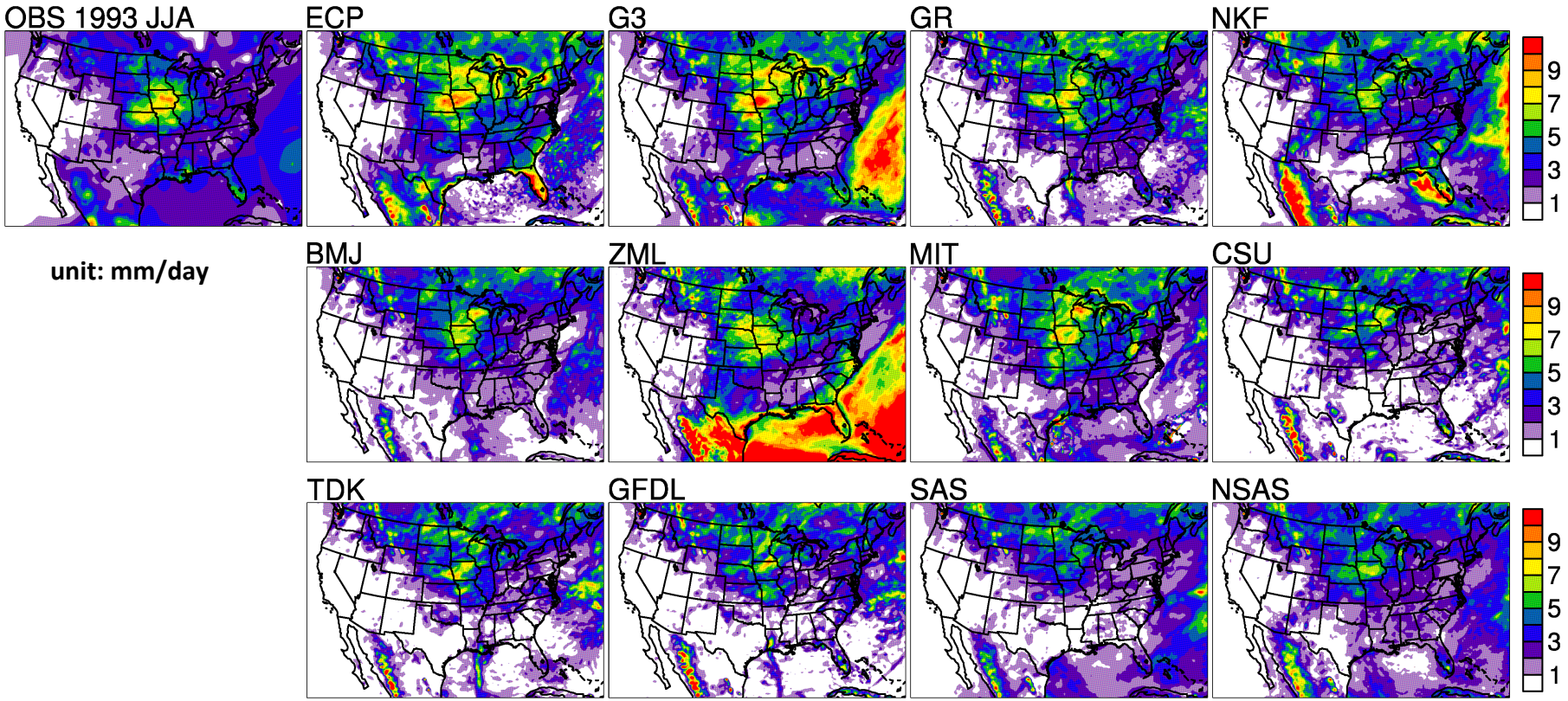
CWRF Physics Options



http://cwrf.umd.edu

CWRF Simulation of 1993 Summer Flood

Comparing 12 widely-used cumulus schemes

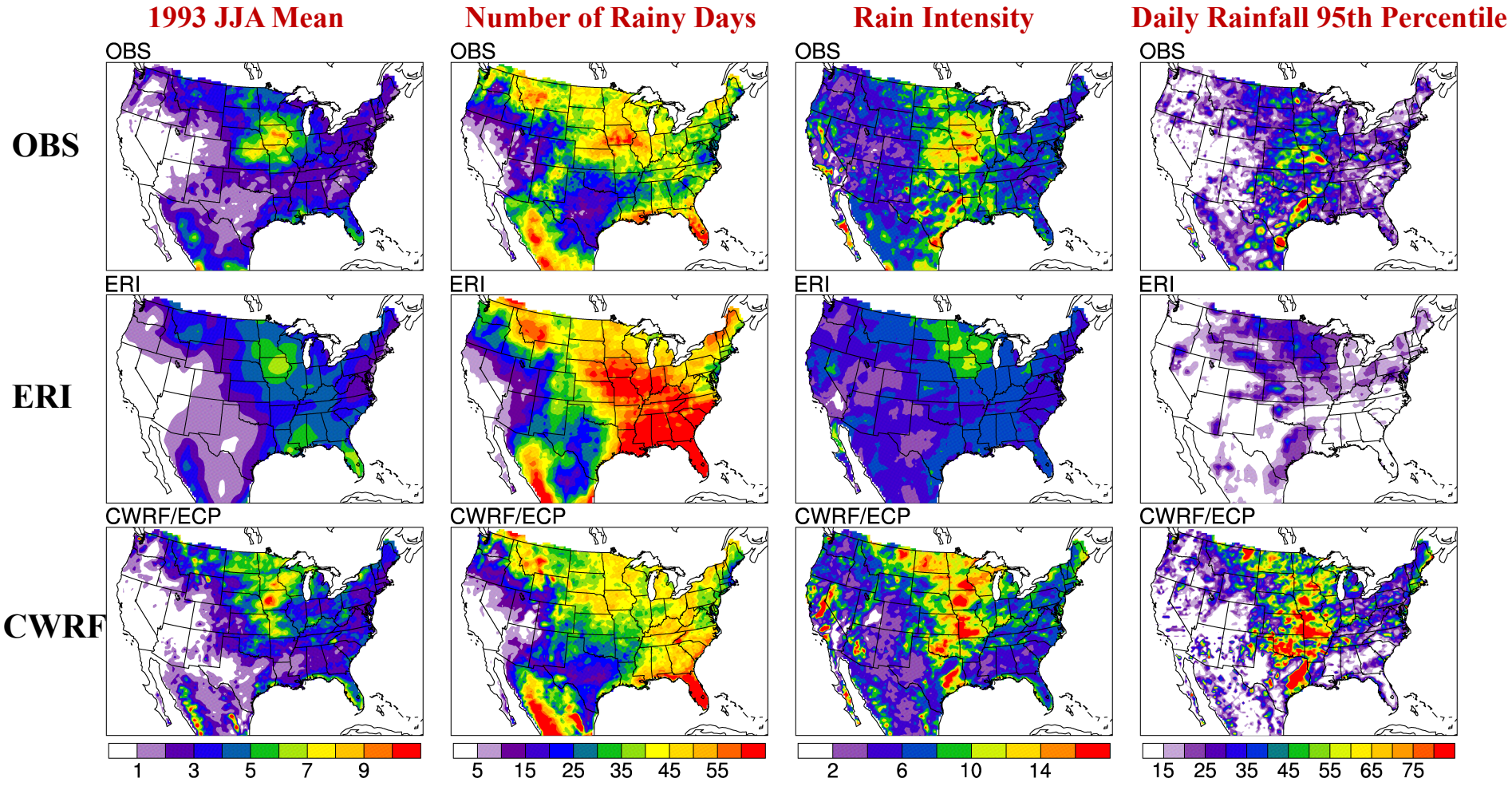


Two problems:

1. ECP most realistically captures the U.S. Midwest flood, but still overestimates the rainfall over the Southeast U.S., implying the moisture convergence closure is not suitable for all the U.S. land area;
2. G3,NKF,ZML schemes all overestimate the precipitation over the U.S. east coastal ocean. However, ECP using cloud work function tendency closure over the ocean significantly alleviates this wet bias.

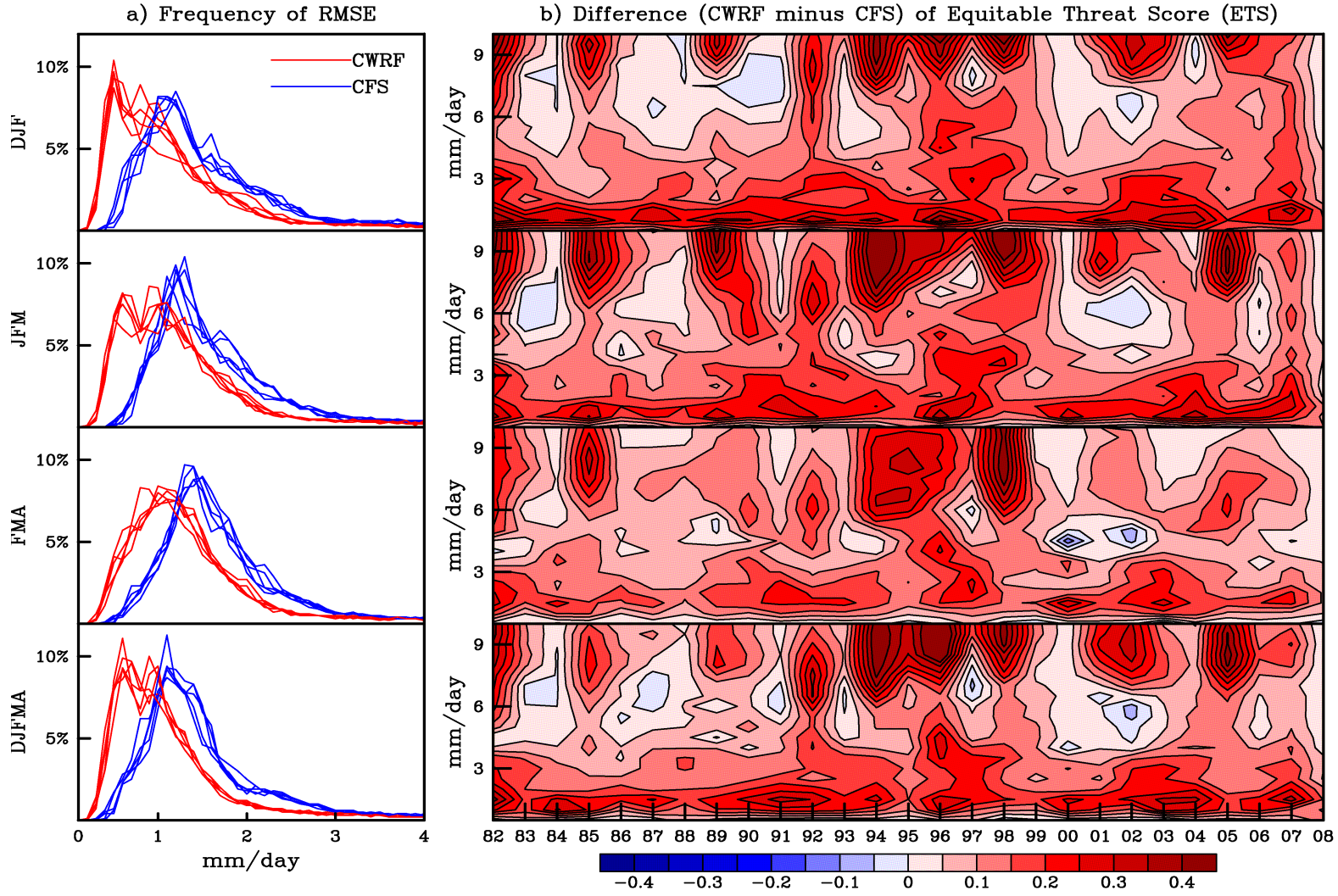
Qiao, F., and X.-Z. Liang, 2014: Effects of cumulus parameterizations on predictions of summer flood in the Central United States. *Climate Dynamics,* 1-18, DOI: 10.1007/s00382-014-2301-7.

CWRF with ECP/W closure over the U.S. land



The reanalysis has already assimilated *local* observational data, while CWRF is driven by only LBCs. The CWRF skill will be enhanced if assimilating local data.

CWRF Improves Seasonal Climate Prediction



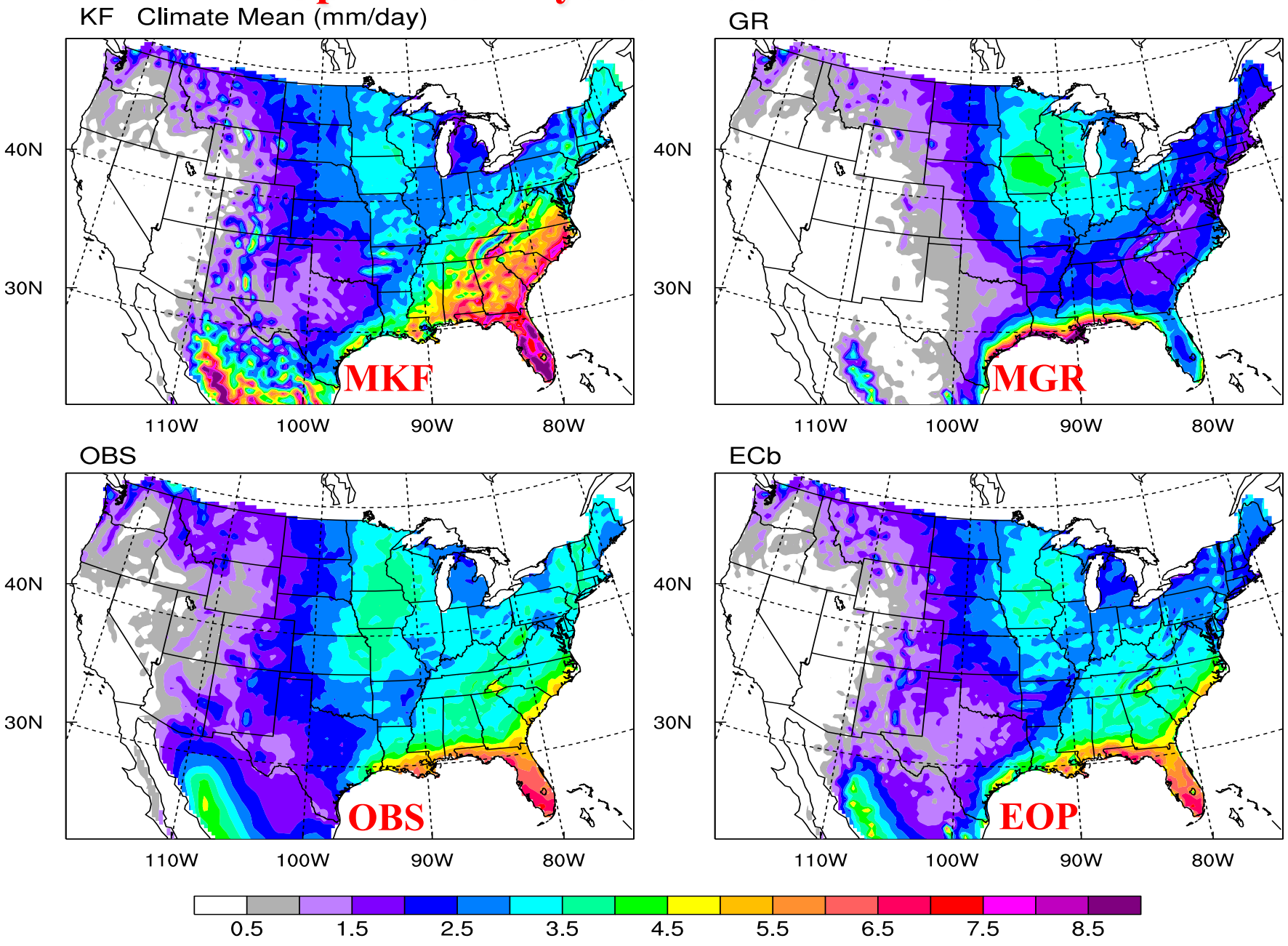
a) Spatial frequency distributions of root mean square errors (*RMSE*, mm/day) predicted by the CFS and downscaled by the CWRF and **b)** CWRF minus CFS differences in the equitable threat score (*ETS*) for seasonal mean precipitation interannual variations. The statistics are based on all land grids over the entire inner domain for DJF, JFM, FMA, and DJFMA from the 5 realizations during 1982-2008. *From* Yuan and Liang 2011 (GRL).

Optimized Physics Ensemble

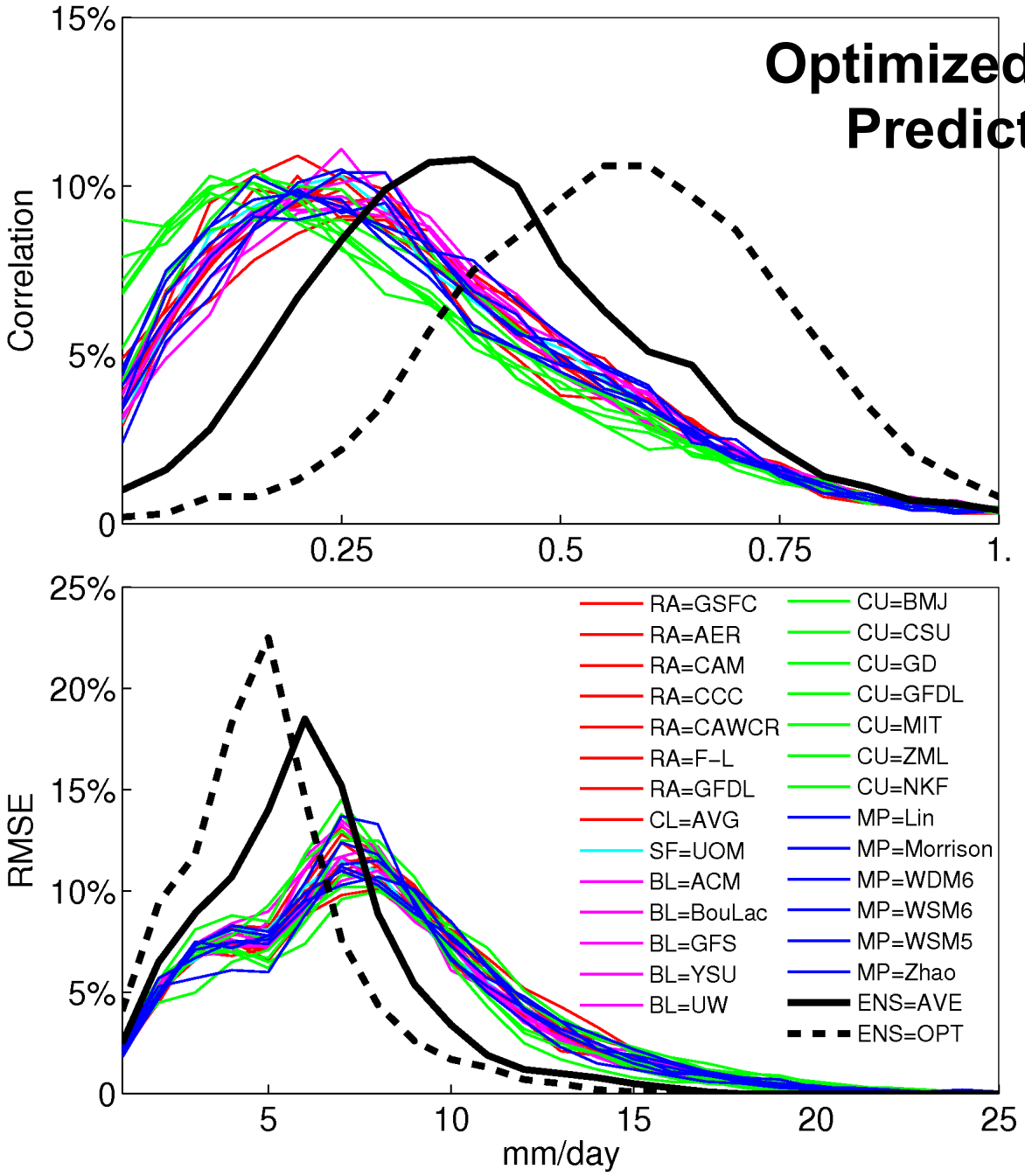
Increasing predictive skill

Quantifying probability / uncertainty

Optimized Physics-Ensemble Prediction



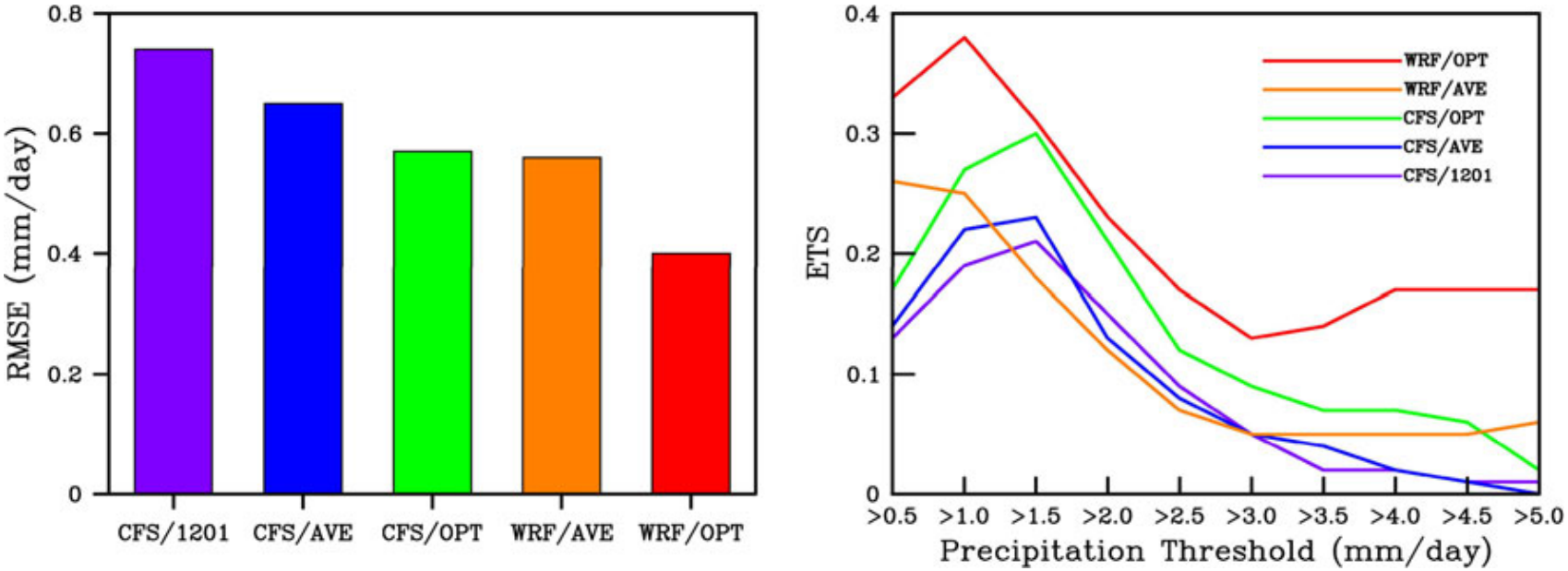
Optimized Physics Ensemble Prediction of Precipitation In summer 1993



The physics ensemble mean substantially increases the skill score over individual configurations, and there exists a large room to further enhance that skill through intelligent optimization.

Spatial frequency distributions of correlations (*top*) and rms errors (*bottom*) between CWRF and observed daily mean rainfall variations in summer 1993. Each line depicts a specific configuration in group of the five key physical processes (*color*). The ensemble result (ENS) is the average of all runs with equal (Ave) or optimal (OPT) weights, shown as *black solid* or *dashed* line.

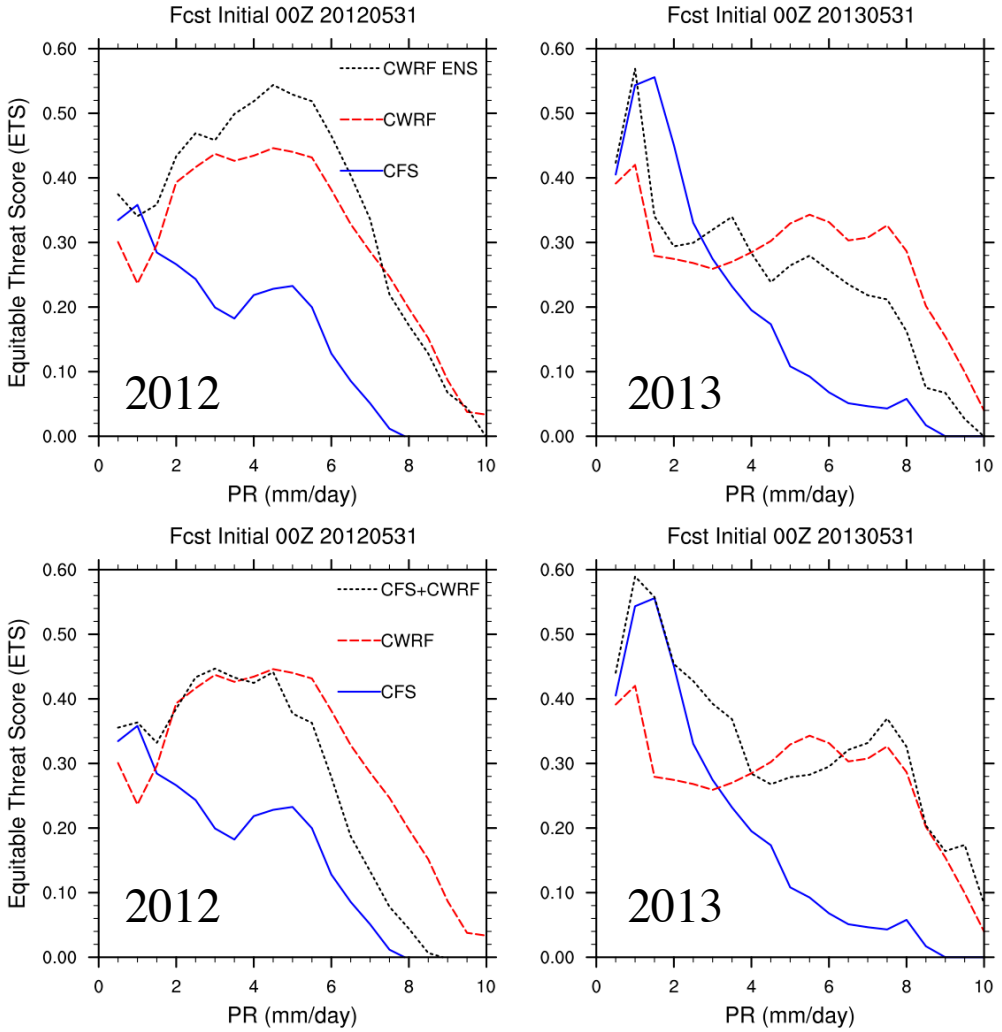
Physics Ensemble Outperforms IC Ensemble



Areal mean RMSE and ETS for the averaged and optimized DJF mean precipitation from CFS and WRF over continental China during 1982–2008. The CFS ensemble consists of 15 forecast members from different initial dates. The WRF ensemble includes 16 physics configurations from two schemes each of cloud microphysics, cumulus convection, land surface, and radiation.

Yuan, X., X.-Z. Liang, and E.F. Wood, 2011: WRF ensemble downscaling seasonal forecasts of China winter precipitation during 1982-2008. *Climate Dynamics*, DOI: 10.1007/s00382-011-1241-8.

CWRF improves CFS real-time U.S. summer precipitation seasonal prediction



The CWRF downscaling enhances CFS precipitation prediction skill in medium-heavy range. Its multi-physics ensemble has the potential to further enhance the skill (the result shown has insufficient size, containing only 4 members).

The CFS-CWRF hybrid ensemble enhances precipitation prediction across the range. Superensemble of CFS multi realizations driving CWRF multi physics runs has the potential to further enhance the skill (the result shown each has a single member).

Liu, S., J.X.L. Wang, X.-Z. Liang, V. Morris, and S.S. Fine, 2014: A hybrid approach to improve U.S. seasonal climate outlook skills at the regional scale. *Climate Dynamics* (accepted).

Optimized Physics Ensemble Improves Predictions

- CWRF includes advanced physics schemes that enable important skill enhancements at regional-local scales to climate forecasts
- CWRF builds upon a super ensemble of alternative physics schemes for skill optimization and probability quantification
- CWRF optimized physics ensemble has a great potential to improve NCEP operational forecasts, especially for extreme events at regional-local scales
- Long-range outlook of severe weather activity may be possible by nesting operational global climate forecasts with RCM OPE